# CRITERIA AIR EMISSIONS AND WATER USE FACTORS FOR GAS AND ELECTRICITY EFFICIENCY SAVINGS FOR THE 2013 CALIFORNIA BUILDING ENERGY EFFICIENCY STANDARDS

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## Introduction

Public Resources Code Section 25402 requires the Energy Commission to adopt, implement, and periodically update energy efficiency standards for both residential and nonresidential buildings.  The enabling statute stressed the importance of building design and construction flexibility by requiring the Energy Commission to establish performance standards, in the form of an "energy budget" in terms of the energy consumption per square foot of floor space, and to support the performance Standards with compliance software to do the necessary energy calculations.  The Building Energy Efficiency Standards include a basic set of mandatory requirements that apply in all cases as well as performance standards that establish energy budgets that vary by climate zone and building type.

The implementation of the 2013 Standards may reduce statewide annual electricity consumption by approximately 470 gigawatt-hours per year (GWh/yr), electrical peak demand by 150 megawatts (MW), and natural gas consumption by 12 million therms per year.

The potential effect of these energy savings to air quality are a net reduction in the emission of nitric oxide (NOx) by approximately 66 tons per year, sulfur oxides (SOx) by 2 tons/year, carbon monoxide (CO) by 40 tons/year and particulate matter less than 2.5 microns in diameter (PM2.5) by 10 tons per year.  Additionally, Energy Commission staff estimates that the implementation of the 2013 Standards may reduce statewide carbon dioxide equivalent ($CO_{2E}$) emissions by 268 thousand metric tonnes per year.

The implementation of the proposed changes to the Building Energy Efficiency Standards is expected to decrease statewide water consumption.  These saving come from onsite sources such as building cooling towers and single-family water heating distribution system improvements, as well as at California power plants from the overall reduction in electric power demand from the proposed energy efficiency improvements.  The Energy Commission estimates that there will be an overall decrease of more than 330 million gallons (approximately 1,000 acre-feet) per year of water consumption from the implementation of the proposed changes to the Building Energy Efficiency Standards.

The emission reduction estimates associated with the reduction of natural gas use are based on the general emission factors for residential and commercial space heating and domestic hot water equipment.

However, the emission estimates associated with the reduction in electricity use are associated with generation throughout the Western United States, Western Canada and Mexico, which is generally controlled by the Western Electricity Coordinating Council (WECC).  California is a net importer of electricity, obtaining approximately 20 to 40 percent of its electricity from WECC in any given hour. That electricity is generated by a combination of sources that may include nuclear, hydroelectric, natural gas, coal and possibly other types of power plants.

The estimated reduction of greenhouse gas emissions additionally include the emission reductions of carbon dioxide ($CO_2$) as well as other associated greenhouse gas, such as nitrous oxide ($N_2O$), methane ($CH_4$) hydrofluoric carbons, halogen-alkenes and sulfur hexafluoride.

This staff paper describes the development of the air emissions and water savings factors used to estimate savings from the adoption of the 2013 Building Energy Efficiency Standards.


## Emission Factors for Natural Gas

The emission factors used for the natural gas saving were taken in whole from the United State Environmental Protection Agency (EPA) AP-42 Compilation of Air Pollution Emission Factors.

An emissions factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant

In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category (i.e., a population average).

The general equation for emissions estimation is:
$E = A \times EF \times (1-ER/100)$

where:
E = emissions;
A = activity rate;
EF = emission factor, and
ER =overall emission reduction efficiency, %

AP-42, Compilation of Air Pollutant Emission Factors, has been published since 1972 as the primary compilation of EPA's emission factor information. It contains

emission factors and process information for more than 200 air pollution source categories. A source category is a specific industry sector or group of similar emitting sources. The emission factors have been developed and compiled from source test data, material balance studies, and engineering estimates.

The emission factors provided in AP-42 include emission factor ratings (A through F), which indication the robustness, or appropriateness, of emission factors for estimating average emissions for a source activity.

Since actual representative source-specific data cannot be obtained due to the scope of the 2013 Standards, Energy Commission staff determined that the use of AP-42 emission factors was the necessary last resort.

Energy Commission staff made the simplifying assumption that the natural gas burning equipment in both residential and nonresidential buildings would all be most reasonably represented by the emission factors for *Uncontrolled Residential Furnaces* as defined by Chapter 1 External Combustion Sources, Section 1.4 Natural Gas Combustion, Page 1.4-1 (see Table 1).

## Table 1
## AP-42 Emission Factors Chosen
## (pounds per million standard cubic foot)

| Pollutant | Emission Factor | Rating |
|-----------|-----------------|--------|
| NOx | 94 | B |
| CO | 40 | B |
| $CO_{2e}$ | 120,000 | A |
| PM | 7.6 | D |
| SOx | 0.6 | A |

Relevant Notes from AP-42 Tables 1.4-1 and 1.4-2:
All Emission factors are based on an average natural gas higher heating value of 1,020 Btu/scf.

$CO_{2e}$ is based on approximately 100% conversion of fuel carbon to CO2. CO2[lb/106 scf] = (3.67) (CON)(C)(D), where CON = fractional conversion of fuel carbon to CO2, C = carbon content of fuel by weight (0.76), and D = density of fuel, 4.2x104 lb/106 scf.

PM (total, condensable, and filterable) is assumed to be less than 1.0 micrometer in diameter. Therefore, the PM10 emission factors may be used to estimate PM10, PM2.5 or PM1emissions. Total PM is the sum of the filterable PM and condensable PM. Condensable PM is the particulate matter collected using EPA Method 202 (or equivalent). Filterable PM is the particulate matter collected on, or prior to, the filter of an EPA Method 5 (or equivalent) sampling train.

SOx is based on 100% conversion of fuel sulfur to $SO_2$. Assumes sulfur content is natural gas of 2,000 grains/106 scf.
http://www.epa.gov/ttn/chief/ap42/ch01/final/c01s04.pdf

Energy Commission staff assumed an energy content of 1,050 British thermal units per standard cubic foot (Btu/scf). This is slightly higher than the assumption by the EPA (1,020 Btu/scf), but better represents the energy content of natural gas in California as reported by the California Air Resources Board (CARB 2008).

For the convienece of the analysis, Energy Commission staff converted these emission factors to short tons (2,000 lbs/ton) and million therms (99,976.12 Btu/therm).

**Table 2**
**Avoided Air Emission Factors from the**
**Reduction of Natural Gas Use in California Buildings**

| Units | NOx | SOx | CO | PM2.5 | $CO_{2E}$ |
|---|---|---|---|---|---|
| Tons/Mtherms | 4.4751 | 0.02856 | 1.904 | 0.3618 | 5712.92 |

## Electricity Generation and Emission Displacements from Energy Efficiency Programs

Displaced generation estimates included in different reports and studies are wide ranging and, in some cases, not well documented or supported in publicly available material.  This displacement topic can be  complex and contentious issue since different energy efficiency programs will have a varied effect on the type generation that may be displaced over time.  Furthermore, there are differences between the short-term and long-term effects of an energy efficiency program that must be considered. A simplified displaced generation proxy can be used to reflect likely changes to statewide resource development and system dispatch decisions when considering new energy efficiency programs, which are sufficient for long-term emission impact evaluations.  However, a more detailed analysis would be needed to evaluate the implications of certain energy efficiency program for a specific utility that may have a unique generation portfolio mix that may differs from other regions within California.

Energy Commission staff are using a displaced generation accounting methodology that was used in the 2007 Climate Action Team report[1] for assessing the emission implications of the new Building Standards.  This accounting method is also included in the recent Energy Aware Report[2] published by the Energy Commission.  Staff updated the assumptions for the displacement calculation by applying the latest resource development policies and new generation characteristics.  This accounting methodology reflects current electric system operations and evolving resource procurement requirements, considering how incremental load forecast changes would alter future electricity system investment decisions and as a result, the type of resources that would have been dispatched to meet energy demand avoided by the efficiency measures.

The displacement methodology is based on Energy Commission staff understanding of electricity system operations and findings from a number of different modeling simulation studies conducted over the past decade on the implications of different supply and demand scenarios.  These types of electricity simulation modeling studies provide insights on how different supply and demand options would affect generation dispatch in California and the rest of the western

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[1] Economics Subgroup Climate Action Team, Updated Macroeconomic Analysis of the Climate Strategies Presented in the March 2006 Climate Action Team Report, October 15, 2007
[2] California Energy Commission, Energy Aware Planning Guide, Publication Number CEC-600-2009-013, February2011

system. [3] Key to these kinds of simulation studies is the development of a base case resource plan that reflects current program mandates and conventional generation options needed to satisfy reliability requirements.  Resource scenarios are then developed to consider new policy programs and associated infrastructure requirements to maintain reliability.  Conventional generation (currently natural gas-fired power plants) generally provide energy and capacity for supply adequacy requirements.  New energy efficiency programs and increasing penetration of intermittent renewable generation will mean that the less of the conventional generation resources are needed for supply adequacy, but will be increasingly relied on to provide ancillary services. [4] The differences between the base case resource plan and scenarios dictates the amount of generation and emissions that would be displaced when implementing new energy efficiency programs.  The study design for typical simulation modeling studies is the basis of the simplified approach used for calculating the displaced emissions associated with the proposed Building Standards.

## *Conceptual Framework for the Displacement Analysis*

California's electricity is supplied via a complex system with many interrelated parts that require constant oversight and management. This system of electricity generators, delivery facilities, and energy consumers must constantly adapt so that the amount of electricity generated always matches the amount of electricity consumed. To match supply with demand, electricity systems rely on a portfolio of power plants that use different fuels and have different operating characteristics. California's electricity supply comes from hydroelectric, natural gas, coal, and nuclear- powered generating plants, and a mix of renewable resources. This generation resource mix changes annually, seasonally, daily, and even hourly.

To provide a reliable supply of electricity, the entities that operate California's system must balance supply and demand at every moment of the day. The availability of electricity generation resources depends on the lead-time involved, with some generation technologies needing a full day to start production and others needing only minutes. Some generators also operate at less than their full capacity, but are able to ramp-up generation quickly to meet increased demand for electricity or other contingencies. Certain types of resources, such as nuclear, coal, geothermal, biomass, and cogeneration (joint production of electricity and steam), usually operate at or near full capacity because of technical constraints, cost considerations, or contractual obligations. Other resources, like run-of-river hydroelectric, wind, and solar, operate when conditions allow, and the system operator must take the electricity when produced by these types of generation units. Adding to the complexity of operating the system, utilities have a responsibility to serve customers at the lowest cost that is capable of meeting

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[3] See the following Energy Commission staff report that was prepared for the *2009 Integrated Energy Policy Report* as an example of a system simulation study to evaluate the implications of different supply and demand planning options:  http://www.energy.ca.gov/2009publications/CEC-200-2009-011/CEC-200-2009-011.PDF

[4] MRW & Associates, Framework for Evaluating Greenhouse Gas Implications of Natural Gas-Fired Power Plants in California, Publication Number CEC-700-2009-009, May 2009, page 6-7.

national reliability criteria, environmental constraints, and current state and federal policies.

In the near-term (1 to 4 years), the electricity generation resource that is operating "on the margin" will be ramped down or displaced. Resources that are "on the margin" refers to the generating unit that is serving that last (or the next) increment of load or demand on the system. Generally, this generation resource will have the highest variable operating cost. However, there are some operational considerations, such as requirements for local grid reliability or dispatch decisions for combustion turbines to balance day-ahead scheduled generation, which will push the generation that may be displaced lower in the dispatch stack.

Since nearly all energy efficiency programs are designed to provide benefits over the long-term (5 to 20 years), the generation resource that will reduce or eliminate the need for new resources that would otherwise be built. Newer gas-fired power plants generally have higher efficiencies, and therefore lower operating costs, than older plants and therefore would tend to be called on to run before the older plants. By avoiding the construction of these higher efficiency plants, energy efficiency measures are likely to displace the emissions that would come from these newer plants rather than the emissions from the older, less efficient (and therefore more expensive) plants.

Decisions to procure and invest in new resources are based on supply adequacy and reliability requirements as the demand for electricity grows over time. The lower the load growth due to new energy efficiency programs, fewer new generation facilities are needed over time. This also includes the amount of new renewables now required under California regulations. The amount of new renewables needed to meet state mandates is indexed to the amount of electricity retail sales in California. Since new energy efficiency programs will reduce electricity retail sales, the amount of new renewable needed to meet current state mandates will be lower. There is considerable uncertainty in identifying the type of facility that would not be built in the future when demand is lower; such a determination will be affected by technological advancements. The choice, for example, would change dramatically if electricity storage technologies advance to a point of economic viability.

## *Generation Displacement Equation*

The long-term generation displacement calculation includes the assumptions that new energy efficiency programs will affect the need to build new renewable and other types of generation needed for system reliability. The ability for utilities and generators to take advantage of spot market electricity imports will also decline since conventional generators must operate to provide certain reliability attributes and implementation of new energy programs may increase minimum load constraints.[5] Transmission and distribution losses from delivering generation to load centers must also be considered in a displaced generation calculation.

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[5] California utilities and generators purchase low cost spot market electricity when prices are lower than the generator operating costs. These imports are serving economic benefits by displacing more expensive generators in California. Minimum load constraints means that generators cannot run at

The equation for annual displacement generation calculation follows:

1. *Displaced Renewable Generation (MWh) = Energy Load Reductions from EE programs (MWh) * 33% RPS*

2. *Displaced CA Gas Generation (MWh) = Energy Load Reductions from EE programs * 67% Gas Share * 75% Instate Generation * 7.8% Instate Transmission & Distribution Losses*

3. *Displaced Imports Generation (MWh) = Energy Load Reductions from EE programs * 67% Gas Share * 25% Imports Displacement * 9.8% Imports Transmission & Distribution Losses*

Emission factors associated with the amounts displaced generation in the above calculation is based on the type of generator, plant efficiency rates and carbon content of the fuel used. Criteria emission factors are based on annual average permit levels. The emission factors are multiplied by the displaced generation to derive the amount of reduced emissions.

The analytical approach for the generation displacement equation is similar to the steps needed for a more detailed analysis of the generation changes when using an electricity system dispatch simulation model. Each approach will require an assessment of the new generation needed to maintain system reliability when implementing different program targets, such as increased energy efficiency or renewable generation penetrations. The primary driver of these kinds of analysis is the changing needs for new generation over the forecast period.

## Renewable Generation Assumptions

The Renewables Portfolio Standard (RPS) that was established by legislation[6] sets the target for the required amount of new renewable generation that California utilities must acquire for their resource portfolios. By 2020, each California energy service provider must have a minimum amount of renewable generation that is the equivalent to 33 percent of their retail electricity sales.[7] Since new energy efficiency programs will reduce total retail sales, these programs will also reduce the amount of renewable energy that is required of utilities to meet the RPS. So, each incremental reduction in electricity demand will reduce the equivalent need for new renewable generation by 33 percent. This complicates the estimation of emissions avoided or reduced because renewable resources are assumed to have zero emissions.

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lower capacity factors, so incremental programs that affect demand will end up reducing the spot market electricity imports.

[6] First legislation in 2002 under Senate Bill 1078 (Sher, Chapter 516, Statutes of 2002), accelerated in 2006 under Senate Bill 107 (Simitian, Chapter 464, Statutes of 2006), and expanded under Senate Bill X1 2 (Simitian, Chapter 1, Statutes of 2011).

[7] Electricity retail sales do not include the amounts needed for water pumping loads, which represents a large fraction of the total electricity use in California.

## California Generation

The large amounts of renewable energy being introduced into the system to meet renewable energy goals will require generation resources that have the economic and operational flexibility to support the intermittent nature of wind and solar technologies. The power plants existing today that have this flexibility are the quick start, rapidly increasing output of combustion turbines commonly referred to as "peaking" units. For this reason, California will likely need to continue to add more plants with these characteristics over the next decade. With the reduced demand resulting from new energy efficiency programs and the increased flexibility required by renewable generation, traditional combined cycle plants will not be able to sustain a capacity factor that will make them economically viable, even if they could meet the operational requirements. For these reasons, the combined cycle natural gas power plant of the future will likely be displaced.

The newer combined cycle power plants built within the last three years provide a reasonable proxy for the plant that will be avoided or displaced in the future. These more recent power plants operate with a heat rate of approximately 7,000 British Thermal Unit (Btu)/kWh.[8] However, a different combined cycle configuration may be built in the next decade to provide the ramping and load following system needs to integrate a larger number of intermittent renewable generators. These kinds of combined cycles would likely run at different operating levels throughout the day, which would result in lower efficiency levels and higher emissions. Staff is assuming that the high ramping generation configuration will lower the efficiency by 15 percent, shifting the heat rate up to 8,000 Btu/MWh. Staff is using both combined cycle configurations to present a range of potential emission displacement factors. This range captures a degree of uncertainty associated with possible investment decisions to integrate new renewable generation development.

The corresponding emission factors for combined cycle units operating with the assumed range of heat rates are 810 lbs $CO_2e$ per MWh for the efficient combined cycles and 932 lbs lbs $CO_2e$ per MWh for high ramping plants. The criteria emission factors are based on Air Quality Management District permit levels, found in Table 3.

### Table 3
### Criteria Pollutant Permit
### Emission Factors

| | | |
|---|---|---|
| NOx | 0.07 | lbs/MWh |
| SOx | 0.01 | lbs/MWh |
| CO | 0.1 | lbs/MWh |
| PM2.5 | 0.03 | lbs/MWh |

## Electricity Imports

Energy Commission staff conducted electricity system simulation modeling of different resource development and energy efficiency program penetration levels

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[8] For more detail on the operations of existing natural gas-fired generation in California please see California Energy Commission staff paper: Michael Nyberg, California Energy Commission, Thermal Efficiency Of Gas-Fired Generation In California, Publication Number CEC-200-2011-008, August 2011.

to determine changes in generation dispatch. The simulations show that incremental load reductions from energy efficiency programs will displace combined cycle generation located both in California and out-of-state regions. Approximately 75 percent of the displaced gas-fired generation occurs in California and the balance from electricity imports.

## Transmission and Distribution Losses

Transmission and distribution losses should also be considered in the displacement calculation since energy efficiency programs will reduce demand at the load centers. Generators must operate at higher levels to make up for the transmission and distribution losses incurred when delivering electricity to the consumer. Measuring actual transmission losses has been difficult and utilities have reported different values at various proceedings, discussed in a recent Energy Commission staff report.[9]

The annual average difference between electricity consumption levels and the amount electricity generated and imported to California is approximately 7.8 percent. Staff considers this to be a reasonable transmission and distribution loss factor for the displacement calculation. This is the same loss factor that the California Air Resources Board is using for the greenhouse gas emission inventory calculations and Mandatory Reporting Requirements. The electricity imports are measured as the metered power flows at the California border, so an additional loss factor must be added to account for deliveries from remote locations throughout the west. For out-of-state sources of electricity (25 percent of generation), staff considers that an additional 2 percent loss factor is reasonable. This imports loss factor is also used by the Air Resources Board.

## Resulting Displaced Emission Factors

The resulting energy efficiency emission displacement factors for GHG emissions range between 588 lbs CO2e per MWh and 676 lbs CO2e per MWh. The California criteria emission displacements are 0.051 lbs NOx per MWh, 0.007 lbs SOx per MWh, 0.072 lbs CO per MWh and 0.022 lbs PM2.5 per MWh. The GHG emission factor is the average for both in-state and out-of-state generation displacement. The criteria emission factors only apply to the in-state generation displacements for air quality impact considerations.

## CARB Greenhouse Emission Factor

While the Displacement methodology described above resulted in an appropriate range of factors for greenhouse gas (GHG) emission savings for energy efficiency measures in California, the prevailing assumptions developed by the California Air Resources Board (CARB) are the more appropriate value to use to maintain consistency across state agencies. The CARB GHG Emission Factor for electricity savings in-state in California: 437 g/kwh (963 lbs/kwh) [10]. It is appropriate to note that the current revisions of the CARB GHG emission factor

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[9] Lana Wong, California Energy Commission, A Review of Transmission Losses in Planning Studies, Publication Number CEC-200-2011-009, August 2011

[10] California Air Resources Board (CARB 2008), Adams, L.S., Nichols, M.D., Goldstene, J. N., Climate Change Scoping Plan, December 2008. Appendix I, pge 20.

is falling more in line with the Displacement method that is preferred by Energy Commission staff.

# Water Savings from Energy Efficiency Programs

## *Onsite Water Savings*

The proposed changes to the mandatory nonresidential requirements in section 110.2, mandatory residential requirements in section 150.0 and prescriptive residential requirements in section 150.1 of the Building Energy Efficiency Standards are expected to result in a substantial savings in onsite water use. These savings are the result of increased hot water pipe insulation, hot water piping design requirements and blowdown and make-up water control requirements for buildings employing cooling towers.

### Single Family Water Heating Distribution System Improvements

The suggested changes to Section 150.0 and 150.1, use new field information and more advanced evaluation tools to generate new mandatory and prescriptive requirements for single family residential buildings. The mandatory requirements include insulating ¾-inch or larger hot water piping from the water heater to the use points (Section 150.0 (j)(2)) and limiting 1-inch hot water piping to a maximum length of 15 feet (Section 150.0 (j)(4)). The prescriptive requirements (Section 150.1) limit the prescribed length of hot water distribution systems between the water heater and the use points[11]. The added insulation is expected to save 1,820 gallons per year of water for each new single-family residential building. The mandatory limit on the length of 1-inch piping is expected to save 730 gallons per year per building and the prescriptive requirement for a compact hot water distribution system is expected to save 2,550 gallons per year per application. Statewide, these requirements are expected to save approximately 121 million gallons (370 acre-feet) of water per year.

### Cooling Tower Water Savings

The suggested changes to Section 110.2(e) would be mandatory requirements that apply to evaporative cooling towers 150 tons and larger, installed in newly constructed buildings and additions and alterations to existing building projects for nonresidential and industrial buildings covered under Title 24. Although the standards include mandatory requirements for heat rejection systems (specifically, fan speed control, tower flow turndown, and a limitation on centrifugal fan cooling towers), there is no existing requirement in the standards that directly addresses water use in cooling towers.

The proposed cooling tower water savings measures require the installation of controls that automate blowdown and chemical feed based on conductivity or flow rate, while maximizing cycles of concentration based on local water quality conditions. Building HVAC system designers will be required to calculate and

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[11] California Utilities Statewide Codes and Standards Team. 9/1/2011. Single Family Water Heating Distribution System Improvements. Page 7, 17-26.

document the maximum cycles of concentration based on local water quality conditions. The measure also requires the installation of a flow meter on the makeup water line, an overflow alarm to prevent overflow of the sump in case of makeup water valve failure, and efficient drift eliminators[12].

The estimated onsite water savings for a typical building using a cool tower (i.e., 117,000 square feet, nonresidential building using a 350 ton cooling tower) would be approximately 86 thousand gallons per year per building or 32.2 million gallons per year statewide.

## Estimated Statewide Onsite Water Savings

There will be an expected decrease of approximately 153 million gallons (470 acre-feet) per year of onsite water consumption from the implementation of the proposed changes to the Building Energy Efficiency Standards.

## *Estimated Statewide Power Plant Water Savings*

The implementation of the proposed changes to the Building Energy Efficiency Standards will result in electricity saving of approximately 470.3 gigawatt-hours per year[13]. These savings will result in water savings at power plants that use evaporative water-cooling as their main source of heat rejection to the environment. Power plant water savings can be estimated by using available the power plant data for California power plants and the described Displacement method (see above) per electricity savings.

## California Power Plant Water Consumption

Electricity generators in California submit data to the Energy Commission through the Quarterly Fuel and Energy Report (QFER) data collection. QFER Data is the annual calculation of net system power as required by state law (Public Utilities Code, § 398.1 - 398.5)[14].

California electric utilities, also referred to as energy service providers, must disclose the generation sources for the power serving their customer loads. Net system power represents the remaining mix of generation resources not included in the utility disclosure filings but that are used to serve California load. These data collections include electricity generation and water use (for the purpose of electricity generation) at California power plants.

From this data, modern combined cycle power plants , which are the likely source of water savings resulting from energy efficiency measures in California, use an average of 522 gallons of water per megawatt-hour of electricity generation per year. This is the average (weighted by the electricity generation at each powerplant) of all existing combined cycle power plants greater than 20

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[12] California Utilities Statewide Codes and Standards Team. 10/1/2011. Cooling Tower Water Savings. Page 6, 20.

[13] Loyer, J. Initial Study/Proposed Negative Declaration For The 2013 Building Energy Efficiency Standards For Residential And Nonresidential Buildings. March 2012. Page 5, Table 1.

[14] Nyberg, M. 2008 Net System Power Report. July 2009. CEC-200-2009-010-CMF.

megawatts in capacity within California.  Table 4 (below) shows the power plants that were considered for this analysis, their individual water use, facility wide electricity generation for 2010, generation based weighting factor and their individual contribution to the average water savings factor.

## Table 4
## Water Use and Electricity Generation Date for
## Combined Cycle Power Plants in California

| PlantName | Capacity (MW) | Total Water Use (gallons per year) | 2010 Electricity Generation (Net MWhr) | Gross Water Use Rate (gallons per MWhr) | Weighting Factor by Generation | Weighted Gross Water Use gallons/MWhr |
|---|---|---|---|---|---|---|
| Total Energy Facilities | 35.2 | 10,750,176 | 134664.13 | 79.82954332 | 0.001382649 | 0.11037626 |
| Calpine King City Cogeneration | 130.0 | 88,683,458 | 589762 | 150.3716041 | 0.006055317 | 0.91054774 |
| Watson Cogeneration Co | 398.0 | 1,349,848,093 | 3016350.01 | 447.510431 | 0.030970045 | 13.85941818 |
| SPAC | 174 | 261,737,835 | 635914 | 411.5931321 | 0.006529178 | 2.687364696 |
| Cardinal Cogen | 52.8 | 47,468,330 | 406795 | 116.6885778 | 0.004176723 | 0.487375905 |
| Carson Cogen | 49.5 | 149,334,446 | 347546 | 429.6825341 | 0.003568391 | 1.533275149 |
| Carson Ice CG | 125.5 | 147,463,277 | 334469.05 | 440.8876606 | 0.003434125 | 1.514063126 |
| Chevron Richmond Refinery Cogeneration | 155.7 | 20,049,117 | 1012960.33 | 19.79259883 | 0.01040046 | 0.205852128 |
| Chevron El Segundo Refinery | 137.1 | 133,217,944 | 968252.24 | 137.585991 | 0.009941424 | 1.367800722 |
| Altivity Packaging - Santa Clara | 25.0 | 24,297,429 | 199515 | 121.7824674 | 0.002048499 | 0.249471204 |
| Pitchess Cogeneration Station | 28.7 | 143 | 203972 | 0.000701077 | 0.00209426 | 1.46824E-06 |
| Crockett Cogeneration Project | 247.4 | 191,810,720 | 1412706.01 | 135.7753975 | 0.014504805 | 1.969395664 |
| Donald Von Raesfeld Power Plant (DVR) | 147.0 | 159,335,695 | 446133.01 | 357.1484097 | 0.004580622 | 1.635961884 |
| Dai Oildale | 31.0 | 110,292,140 | 177089 | 622.8062726 | 0.001818242 | 1.132412528 |
| El Centro Cogen | 279 | 236,504,089 | 576678.14 | 410.1145381 | 0.00592098 | 2.428279959 |
| Roseville Energy Park (REP) | 200.0 | 17,850,700 | 500448 | 35.66944018 | 0.005138295 | 0.183280117 |
| O.L.S. Energy - Agnews | 30.5 | 69,330,970 | 209909 | 330.2906021 | 0.002155218 | 0.711848179 |
| Calpine Gilroy Cogen | 123.4 | 101,274,383 | 160653.02 | 630.3920275 | 0.001649487 | 1.03982369 |
| Grayson | 287.0 | 104,127,033 | 184949.48 | 563.0025724 | 0.001898949 | 1.069112963 |
| Calpine Greenleaf | 72.0 | 74,664,988 | 245816 | 303.7434016 | 0.002523889 | 0.766614627 |
| Harbor | 597.0 | 5,401,000,000 | 216151 | 24987.16175 | 0.002219307 | 55.45417888 |
| Harbor Cogen | 107 | 12,547,700 | 21293.16 | 589.2831313 | 0.000218625 | 0.128832142 |
| Haynes | 1629.0 | 26,448,000,000 | 4393034.14 | 6020.440351 | 0.045104999 | 271.5519576 |
| Kingsburg Cogeneration | 34.5 | 43,768,676 | 103897 | 421.269873 | 0.001066751 | 0.449390111 |
| Magnolia | 309.7 | 420,901,013 | 1659954 | 253.5618535 | 0.017043397 | 4.32155528 |
| Moss Landing Units 1 & 2 | 1080 | 214,000 | 3506345.13 | 0.061032212 | 0.036001016 | 0.002197222 |
| Moss Landing Units 6 & 7 | 1404 | 596,000 | 3506345.13 | 0.169977563 | 0.036001016 | 0.006119355 |
| Fresno Cogeneration Partners LP | 58.3 | 3,799,792 | 12803.12 | 296.7854083 | 0.000131455 | 0.03901395 |
| NTC MCRD Energy Facility | 25.6 | 46,958,079 | 158344.02 | 296.557325 | 0.00162578 | 0.482136959 |
| North Island Energy Facility | 38.6 | 63,494,124 | 325044 | 195.3400893 | 0.003337354 | 0.651918998 |
| OLS Energy Camarillo | 31.2 | 22,974,120 | 226940 | 101.2343051 | 0.002330082 | 0.235884273 |
| OLS Energy Chino | 31.2 | 79,992,883 | 233466 | 342.6318308 | 0.002397087 | 0.821318208 |
| PE Berkeley Inc | 26.4 | 2,592,000 | 201361 | 12.8724033 | 0.002067452 | 0.026613078 |
| Sacramento SCA | 193 | 292,649,016 | 753698.01 | 388.2841829 | 0.007738512 | 3.004741878 |
| Redding Power | 141 | 3,027,365 | 21955.21 | 137.8882279 | 0.000225423 | 0.03108314 |
| Sanger Power LLC | 39.8 | 45,454,080 | 130311.09 | 348.812062 | 0.001337955 | 0.466694813 |
| Foster-Wheeler Martinez Cogen | 127 | 293,703,793 | 789003 | 372.246738 | 0.008101002 | 3.015571686 |
| Naval Station Energy Facility | 49.9 | 126,120,620 | 321630 | 392.1295277 | 0.003302301 | 1.294929721 |
| United Cogen | 31 | 51,008,324 | 186884 | 272.9410972 | 0.001918811 | 0.523722408 |
| USD Cogeneration Facility | 30 | 29,577,283 | 195894 | 150.9851593 | 0.00201132 | 0.303681527 |
| Valley Generating Station | 573 | 24,531,176 | 1543308 | 15.89519137 | 0.015845747 | 0.251871176 |
| Calpine Monterey Cogeneration, Inc. | 30.8 | 16,847,260 | 66407.14 | 253.6965152 | 0.000681828 | 0.172977406 |
| Wheelabrator Norwalk Energy | 30.8 | 11,943,586 | 88659 | 134.7137459 | 0.000910297 | 0.122629468 |
| Woodland | 146.0 | 87,626,734 | 363528 | 241.04535 | 0.003732484 | 0.899697942 |
| Yuba City Cogeneration Partners LP | 100 | 97,189,716 | 789883 | 123.0431798 | 0.008110038 | 0.997884817 |
| Martinez Refinery | 35.0 | 109,519,790 | 109846.12 | 997.0292078 | 0.001127833 | 1.124482508 |
| ConocoPhillips Los Angeles Refinery | 43.0 | 207,830,852 | 285953 | 726.80074 | 0.002935991 | 2.133880623 |
| UCLA Energy Systems Facility | 726.7 | 855,876,979 | 14823.72 | 57736.99038 | 0.000152201 | 8.787623606 |
| Elk Hills CoGeneration | 83.0 | 650,436 | 436697 | 1.489444626 | 0.004483739 | 0.006678281 |
| Shell Oil - Los Angeles Refining | 854.9 | 700,308,996 | 3279553 | 213.5379413 | 0.033672453 | 7.190346295 |
| High Desert Power Project | 552 | 48,390,706 | 1815442 | 26.6550548 | 0.018639853 | 0.4968463 |
| Sutter - Calpine | 594 | 1,008,622,061 | 3326116 | 303.2432005 | 0.034150534 | 10.35591709 |
| Los Medanos Energy Center LLC | 1200 | 5,644,727 | 5288401 | 1.067378779 | 0.054298081 | 0.057956619 |
| La Paloma Generating | 850 | 768,456,209 | 3996277 | 192.2930291 | 0.041031339 | 7.89004038 |
| Calpine - Delta | 572 | 802,097,974 | 3254247 | 246.4772877 | 0.033412626 | 8.235453533 |
| Sunrise Power | 689 | 32,631,486 | 2160093.03 | 15.10651881 | 0.02217852 | 0.335040226 |
| Otay Mesa Generating Project | 591 | 574,391,221 | 1266892.06 | 453.3860769 | 0.013007676 | 5.897499263 |
| Blythe Energy LLC | 565.8 | 609,845,333 | 2590369 | 235.4279769 | 0.026596331 | 6.261520494 |
| Metcalf Energy Center, LLC | 1054.0 | 1,527,454,758 | 6051142 | 252.4242131 | 0.062129441 | 15.68297526 |
| Mountainview Power Company LLC | 778.0 | 925,756,093 | 4335307 | 213.5387628 | 0.044512292 | 9.505099794 |
| Pastoria Energy Facility L.L.C. | 567.0 | 1,075,309,710 | 3753116 | 286.5111843 | 0.03853471 | 11.04062526 |
| CalPeak Power - Border | 559 | 879,518,184 | 3198928 | 274.9415379 | 0.032844645 | 9.030357102 |
| Palomar Energy Center | 559 | 917,942,699 | 3198928 | 286.9532228 | 0.032844645 | 9.424876622 |
| Inland Empire Energy Center | 810.0 | 964,194,250 | 3597388.03 | 268.0262018 | 0.03693579 | 9.899759381 |
| Consumnes Power Plant | 500.0 | 27,289,657 | 3738727 | 7.299184188 | 0.038386972 | 0.280193579 |
| Malburg Power Plant | 139.4 | 239,811,760 | 721222 | 332.5075497 | 0.007405068 | 2.46224111 |
| Walnut Energy Center | 250.0 | 359,479,296 | 1536661 | 233.9353285 | 0.015777499 | 3.690914494 |
| Clearwater | 29.0 | 6,289,485 | 7155.1 | 879.0212576 | 7.34642E-05 | 0.064576602 |
| Gateway Generating Station | 613.1 | 16,771,573 | 3099375 | 5.411275822 | 0.031822495 | 0.172200298 |
| Termoelectrica de Mexicali (TDM) | 680.9 | 661,716,181 | 2848153.06 | 232.3316785 | 0.029243101 | 6.794098773 |
| La Rosita (INTERGEN, Mexicali, Mexico) | 676.5 | 598,726,878 | 1904194.09 | 314.425342 | 0.019551105 | 6.147362969 |
| **Totals** | **24,176.06** | **50,849,085,600.23** | **97,395,725.78** | **106,830.55** | **1.00** | **522.09** |

Source: Water Factor 2012.xlsx

However, as has been demonstrated, a megawatt-hour of electricity saved by the Standards will not translate into a megawatt-hour of generation avoided by California power plants. Using the Displacement method (see above discussion), the most appropriate water savings factor to use is approximately 377 gallons of water would be saved at power plants in California for each megawatt-hour of electricity saved through energy efficiency measures.

### Estimated Statewide Power Plant Water Savings

The Energy Commission expects a savings of approximately 177 million gallons of water (540 acre-feet) per year from the electricity generation avoided at California power plants as a result of the implementation of the proposed changes to the Building Energy Efficiency Standards.

## Total Savings in Water Consumption

The total of both the expected statewide onsite water savings and the expected water savings at California power plants is approximately 330 million gallons per year, which is over 1,000 acre-feet per year.